

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
 US Department of Commerce
 United States Patent and Trademark
 Office, PCT
 2011 South Clark Place Room
 CP2/5C24
 Arlington, VA 22202
 ETATS-UNIS D'AMERIQUE
 in its capacity as elected Office

Date of mailing (day/month/year)

09 April 2001 (09.04.01)

International application No.

PCT/EP00/07285

Applicant's or agent's file reference

WO 17.0191

International filing date (day/month/year)

25 July 2000 (25.07.00)

Priority date (day/month/year)

05 August 1999 (05.08.99)

Applicant

CHYZAK, Jean-Pierre et al

1. The designated Office is hereby notified of its election made:



in the demand filed with the International Preliminary Examining Authority on:

23 February 2001 (23.02.01)



in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
 34, chemin des Colombettes
 1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

S. Mafla

Telephone No.: (41-22) 338.83.38

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**NOTICE INFORMING THE APPLICANT OF THE
COMMUNICATION OF THE INTERNATIONAL
APPLICATION TO THE DESIGNATED OFFICES**

(PCT Rule 47.1(c), first sentence)

From the INTERNATIONAL BUREAU

To:

MENES, Catherine
Etudes & Productions Schlumberger
26, rue de la Cavée
Boîte postale 202
F-92142 Clamart Cedex
FRANCE

44 23/2/01

Date of mailing (day/month/year) 15 February 2001 (15.02.01)		
Applicant's or agent's file reference WO 17.0191		IMPORTANT NOTICE
International application No. PCT/EP00/07285	International filing date (day/month/year) 25 July 2000 (25.07.00)	Priority date (day/month/year) 05 August 1999 (05.08.99)
Applicant SCHLUMBERGER TECHNOLOGY B.V. et al		

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
AU,KP,KR,US

In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
AE,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CN,CR,CU,CZ,DE,DK,DM,EA,EE,EP,ES,FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,NO,NZ,OA,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,ZA,ZW
The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
15 February 2001 (15.02.01) under No. WO 01/11190

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a demand for international preliminary examination must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the national phase, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer J. Zahra
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PATENT COOPERATION TREATY

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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference WO 17.0191	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/EP 00/ 07285	International filing date (day/month/year) 25/07/2000	(Earliest) Priority Date (day/month/year) 05/08/1999
Applicant SCHLUMBERGER TECHNOLOGY B.V.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 4 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☐ as suggested by the applicant.

☒ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1
☐ None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 00/07285

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 E21B47/10 G01F1/74

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B G01F G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 251 479 A (SIEGFRIED) 12 October 1993 (1993-10-12) column 4, line 27 - line 29 column 4, line 48 - line 53 column 5, line 49 - line 56 ---	1-5, 7-11, 13, 15
X	GB 2 307 047 A (WESTERN ATLAS INT INC) 14 May 1997 (1997-05-14) cited in the application abstract page 8, line 21 - page 9, line 19 page 10, line 1 - line 5 --- -/--	1, 2, 4-8, 10, 15

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

3 November 2000

Date of mailing of the international search report

10/11/2000

Name and mailing address of the ISA

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Authorized officer

Sogno, M

INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 00/07285

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 631 413 A (YOUNG) 20 May 1997 (1997-05-20) column 11, line 15 - line 20 column 7, line 62 - column 8, line 6 column 13, line 3 - line 30 column 13, line 35 - line 39; figures 2,17 ----	1,7
A	FR 2 732 068 A (SERVICES PETROLIERS SCHLUMBERGER) 27 September 1996 (1996-09-27) cited in the application page 9, line 26 - line 28 page 12, line 32 - page 13, line 2 page 13, line 27 - page 14, line 2 ----	1,7
A	FR 2 761 111 A (SERVICES PETROLIERS SCHLUMBERGER) 25 September 1998 (1998-09-25) cited in the application abstract ----	1,7
A	GB 2 294 074 A (WESTERN ATLAS INT INC) 17 April 1996 (1996-04-17) cited in the application page 10, line 5 - line 9 page 10, line 23 - line 28 page 12, line 12 - line 14 page 16, line 20 - line 25 ----	1,7
A	GB 2 313 196 A (WESTERN ATLAS INT INC) 19 November 1997 (1997-11-19) cited in the application page 5, line 28 - page 6, line 1 ----	1,7
A	GB 2 301 675 A (WESTERN ATLAS INT INC) 11 December 1996 (1996-12-11) page 6, line 15 - line 28 page 8, line 19 - line 22 page 3, line 29 - page 4, line 2 ----	1,7
A	FR 2 749 080 A (SERVICES PETROLIERS SCHLUMBERGER) 28 November 1997 (1997-11-28) cited in the application abstract page 1, line 18 - line 22 ----	1,7
A	US 5 561 245 A (GEORGI) 1 October 1996 (1996-10-01) column 4, line 16 - line 18 column 4, line 24 - line 33 ----	1,7

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INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 00/07285

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>US 4 435 978 A (GLATZ) 13 March 1984 (1984-03-13) claim 1 column 4, line 3 - line 5 column 5, line 15 - line 22 -----</p>	1,7

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 00/07285

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5251479	A	12-10-1993	NONE	
GB 2307047	A	14-05-1997	US 5633470 A CA 2189084 A NO 964707 A	27-05-1997 08-05-1997 09-05-1997
US 5631413	A	20-05-1997	US 5531112 A CA 2184856 A CA 2147311 A EP 0683304 A NO 951412 A	02-07-1996 08-09-1997 21-11-1995 22-11-1995 21-11-1995
FR 2732068	A	27-09-1996	CA 2172440 A DE 69609220 D EP 0733780 A NO 961191 A US 5661237 A ZA 9602328 A	24-09-1996 17-08-2000 25-09-1996 24-09-1996 26-08-1997 24-10-1996
FR 2761111	A	25-09-1998	AU 5938798 A BR 9800929 A CA 2232922 A EP 0866213 A GB 2323446 A,B JP 10325290 A NO 981237 A ZA 9802341 A	24-09-1998 09-11-1999 20-09-1998 23-09-1998 23-09-1998 08-12-1998 21-09-1998 22-09-1998
GB 2294074	A	17-04-1996	CA 2160176 A NO 954001 A US 5574263 A	15-04-1996 15-04-1996 12-11-1996
GB 2313196	A	19-11-1997	US 5736637 A CA 2203309 A NO 972059 A	07-04-1998 15-11-1997 17-11-1997
GB 2301675	A	11-12-1996	US 5610331 A NO 962198 A	11-03-1997 02-12-1996
FR 2749080	A	28-11-1997	CA 2205746 A EP 0809098 A NO 972323 A US 5956132 A	22-11-1997 26-11-1997 24-11-1997 21-09-1999
US 5561245	A	01-10-1996	NONE	
US 4435978	A	13-03-1984	NONE	

A METHOD AND APPARATUS FOR ACQUIRING DATA IN A
HYDROCARBON WELL IN PRODUCTION

DESCRIPTION

5 **Technical Field**

The invention relates to a data acquisition method and apparatus designed to be used in a hydrocarbon well in production.

10 More precisely, the method and apparatus of the invention are designed to ensure that the production parameters in a hydrocarbon well are monitored, and to enable a diagnosis to be established in the event of an incident.

15 **State of the Art**

To ensure the monitoring and diagnostic functions in hydrocarbon wells in production, a certain amount of data, mainly physical data, has to be acquired. The data essentially relates to the multiphase fluid which flows
20 in the well (flow rate, proportions of its various phases, temperature, pressure, etc.). It can also relate to certain characteristics of the well proper (ovalization, inclination, etc.).

Data that is particularly important for the operator
25 is the average flow rate and the proportion of each of the phases present in the multiphase fluid.

To acquire said data, and as shown in particular by document FR-A-2 732 068, a conventional solution consists in taking, firstly, an overall measurement of the speed
30 of the fluid flowing in the well, by means of a spinner placed in the axis of the well, and secondly, local measurements enabling the proportions of the various phases of the fluid in certain regions of the well to be determined. The speed measurement and the local
35 measurements are taken at various levels. The local measurements are taken by means of local sensors which can be resistivity sensors, optical sensors, etc..

Document FR-A-2 761 111 proposes an improvement to that type of apparatus, in which the overall measurement of the speed of the fluid and the determination of the proportions of the various phases are taken substantially at the same level. Such an apparatus is more compact than conventional apparatuses and avoids certain errors or inaccuracies due to offsets between the measurement points.

To determine the flow rate of the various phases of the fluid flowing in the well, the flow rate of the fluid over the section of the well is calculated from the measurements taken by said existing apparatuses by multiplying the overall speed measured at the center of the well by the section of the well at the place where said measurement is taken. The proportion relating to the phase under consideration as determined by the local sensors is then applied to said overall flow rate.

It is also known that the distribution of the various phases of the fluid flowing in an oil well varies depending on whether the well is vertical, inclined, or horizontal. Because of the difference in density of the various phases of the fluid, said phases become progressively more stratified with increasing inclination of the well. Thus, in the case of a three-phase fluid containing water, oil, and gas, the three phases tend to flow one on top of the other when the well is horizontal or greatly inclined.

To take account of that phenomenon, and as shown in particular in documents GB-A-2 294 074 and GB-A-2 313 196, data acquisition apparatuses have been proposed that are provided with a certain number of local sensors that are distributed in a vertical mid-plane of the well when the tool is brought into its operating position in an inclined or horizontal well.

The arrangement of the local sensors proposed in those documents enables the stratification of the various phases in inclined or horizontal wells to be taken into

account in order to determine their proportions in more reliable manner. However, the technique used to determine the flow rate of each of the phases remains the same and is based on determining the overall flow rate of the fluid in the well.

Document GB-A-2 307 047 proposes a data acquisition apparatus intended for horizontal or greatly inclined wells in which there flows a liquid phase together with a large gas phase. That apparatus has various sensors situated in the gas phase and sensors situated in the liquid phase(s). In addition, it measures the speeds of the gas and the liquid phases separately. It also takes a level measurement, by a capacitive system, so as to determine the proportions of the gas and liquid phases.

That apparatus can only be used in wells that are horizontal or greatly inclined. In other words, it cannot be used in wells that are vertical or slightly inclined. In addition, the level measurement technique used does not determine the real proportions of the various phases of the fluid. An intermediate zone generally exists where the gas and the liquid are mixed, thereby causing the level measurement taken to be highly inaccurate. Furthermore, the frequent presence of two liquid phases, such as water and oil, is not taken into account.

Summary of the invention

An object of the invention is to provide a data acquisition method and apparatus that enable the flow rate of the various phases of a fluid flowing in an oil well to be determined in more accurate and more reliable manner than with existing apparatuses, in particular when the well is inclined or horizontal.

The invention is based on the observation whereby, in an inclined or horizontal well, the flow rate of any one phase of the fluid is not equal to the product of the overall (or average) speed of the fluid multiplied by the

section of the well and by the proportion of said phase in the flowing fluid, but is rather the product of the speed of the phase under consideration multiplied by the section and by the proportion of said phase.

5 Thus, the invention provides a method of acquiring data in a hydrocarbon well, the method being characterized in that it consists in determining both the local speed of a multiphase fluid flowing in the well and the local proportions of the phases of said fluid in each
10 of at least two distinct regions of the well that are offset from each other parallel to the axis of the well.

The regions in which the measurements are taken are preferably all situated in the same plane containing the axis of the well, or in the vicinity of said plane.

15 More precisely, said regions are preferably distributed across the entire width of the well.

To ensure the effectiveness of the measurement in an inclined or horizontal well, the plane in which the measurement regions are situated is advantageously
20 oriented in a substantially vertical direction.

One of said regions is thus preferably situated in the vicinity of a top generator line of the well.

A section element (Δs_i) of the well is advantageously assigned to each of said regions, and the
25 overall flow rate Q of each of said phases is determined from the relationship:

$$Q = \sum_i q_i \cdot \frac{\Delta s_i}{S}$$

where S is the total vertical section of the well
30 and q_i is the flow rate of said phase in section element Δs_i ,

with $q_i = v_i \cdot h_i$

where v_i is the local speed of said phase in section element Δs_i

and h_i is the local proportion of said phase in section element Δs_i .

The invention also provides apparatus for acquiring data in a hydrocarbon well, the apparatus being
5 characterized in that it comprises, in each of at least two distinct regions of the well that are offset from each other parallel to the axis of the well, means for determining the local speed of a multiphase fluid flowing in the well and means for determining the local
10 proportions of the phases of said fluid.

In a preferred embodiment of the invention, the apparatus comprises a body capable of resting, by gravity, against a bottom generator line of the well, and at least one deployable arm supported by the body at one
15 end and capable of being applied against the top generator line of the well, in which at least some of the means for determining the local speed of the fluid and at least some of the means for determining the local proportions of the phases are supported by the deployable
20 arm.

In another preferred embodiment of the invention, the apparatus comprises a body capable of being centered about the axis of the well by centering means including at least two deployable arms supported by the body and
25 capable of being applied respectively against the bottom generator line and against the top generator line of the well, in which at least some of the means for determining the local speed of the fluid and at least some of the means for determining the local proportions of the phases
30 are supported by the deployable arms.

Depending on circumstances, the means for determining the local speed of the fluid and the means for determining the local proportions of the phases can either be included in the multi-sensor assemblies or they
35 can be separate therefrom. When separate, in each of the measurement regions, the means for determining the local speed of the fluid and the means for determining the

local proportions of the phases are substantially in alignment with each other on a line parallel to the axis of the well.

5 **Brief description of the drawings**

Various embodiments of the invention are described below as non-limiting examples, and with reference to the accompanying drawings, in which:

10 Figure 1 is a view in longitudinal section showing in diagrammatic manner data acquisition apparatus constituting a first embodiment of the invention in a greatly inclined well;

Figure 2 is a view in diagrammatic section on line II-II of Figure 1;

15 Figure 3 is a view similar to Figure 1 showing another embodiment of the invention; and

Figure 4 is a section view similar to Figure 1 showing a variant of the first embodiment.

20 **Detailed description of preferred embodiments of the invention**

Figure 1 shows, very diagrammatically, a portion of data acquisition apparatus 10 placed in a hydrocarbon well 12 in production. More precisely, the portion of
25 the well 12 in which the apparatus 10 is situated is inclined so that the multiphase petroleum fluid which flows therein is stratified at least in part. The data acquisition apparatus 10 of the invention is linked to a surface installation (not shown) via a cable or a
30 flexible rod. The data acquired in the apparatus 10 is transmitted in real time to the surface installation, by telemetry, through the cable or the flexible rod.

In modules not shown and which are not part of the invention, the data acquisition apparatus 10 includes a
35 certain number of sensors, such as pressure or temperature sensors. It also comprises a telemetry system.

In the portion shown in Figure 1, the data acquisition apparatus 10 comprises a cylindrical body 14 having a diameter that is substantially smaller than the inside diameter of the well 12. The body 14 supports a
5 deployable mechanism 16 that is capable of being deployed in a plane containing the longitudinal axis of said body.

In the embodiment shown in Figure 1, the mechanism 16 comprises an arm 18 having a downward end hinged on the body 14, and an arm 20 interposed between the other
10 end of the arm 18 and a portion of the body 14 closer to the surface. This end of the arm 20 is capable of being displaced inside the body 14, parallel to its longitudinal axis, by a motor 22. Actuation of the motor 22 enables the mechanism 16 to be displaced between an
15 active position of the apparatus in which said mechanism is deployed in the manner shown in Figure 1, and an inactive position in which the mechanism 16 is retracted inside the body 14.

In a variant embodiment (not shown), the mechanism
20 16 can be constituted by a spring mechanism that is automatically deployed when the apparatus is inserted in the well. The motor 22 can thus be omitted.

In the embodiment of Figure 1, when the apparatus 10 is inserted in an inclined or horizontal well, the body
25 14 automatically remains in the bottom portion of the well, i.e. against the bottom generator line of the well. When the mechanism 16 is deployed, the mechanism then automatically occupies the entire diameter of the well. Consequently, the arms 18 and 20 forming the mechanism 16
30 are automatically positioned above the body 14 in a vertical plane containing the longitudinal axis of the well 12.

In a variant, it is possible to fit the body 14 of the apparatus with a magnetic device. The device co-
35 operates with the metal tubing which lines the inside of the well 12 so as to guarantee that the body 14 is properly oriented in the above-mentioned vertical plane.

In each of at least two distinct regions of the well 12, the data acquisition apparatus 10 comprises means for determining the local speed of the multiphase fluid flowing in the well, and means for determining the local proportions of the phases of said fluid. The various regions in which the measurements are taken are not in alignment with one another parallel to the longitudinal axis of the well.

More precisely, in the embodiment shown in Figures 1 and 2, the apparatus 10 is fitted with five multi-sensor assemblies 24, each including means for determining the local speed of the fluid, and means for determining the local proportions of the phases of said fluid. One of said multi-sensor assemblies 24 is mounted in the body 14 of the apparatus 10 and the other four multi-sensor assemblies 24 are mounted on the arm 18 of the mechanism 16 so as to be distributed evenly across the entire width of the well 12 in the vertical plane containing the longitudinal axis of said well.

One of multi-sensor assemblies 24 mounted on the arm 18 is placed on its end hinged to the arm 20. Consequently, said multi-sensor assembly 24 is situated in the immediate vicinity of the top generator line of the well when the mechanism 16 is deployed.

Figure 2 is a diagram showing the geometrical distribution of the multi-sensor assemblies 24 over the entire width of the well 12 in the vertical plane containing the longitudinal axis of the well.

In practice, each of the means for determining the local speed of the fluid, contained in the multi-sensor assemblies 24, is constituted by a small spinner (not shown). The multi-sensor assemblies 24 are mounted on the arm 18 of the mechanism 16 so that the axes of the spinners are oriented substantially parallel to the longitudinal axis of the well 12 when the mechanism 16 is deployed. This can easily be obtained by mounting the

assemblies 24 on the arm 18 via deformable parallelogram linkages or the equivalent.

In addition, each of the means for determining the local proportions of the phases of the fluid and fitted to each multi-sensor assembly 24, can be constituted by any known means capable of performing this function. Such known means include, in particular, resistivity sensors as described in document EP-A-0 733 780, optical sensors as described in document FR-A-2 749 080, or multiple sensors including two or three optical sensors, or one optical sensor and a resistivity sensor, for example.

In the embodiment in Figures 1 and 2, each of the means for determining the local proportions of the phases can, in particular, be placed in the center of the small spinner serving to measure the local speed of the fluid.

Using the arrangement described above, there are made available both a measurement of the local speed of the fluid and data representative of the local proportions of the phases in each of the local regions occupied by the multi-sensor assemblies 24. In each of the regions in which the multi-sensor assemblies 24 are situated, the flow rate value of each of the phases entering into the composition of the petroleum fluid circulating in said region of the well can therefore be calculated accurately. The total flow rate is then determined for each of the phases by adding together, for all of the regions, the values of the previously calculated flow rates.

A measurement is thus obtained of said flow rates that is substantially more accurate than the measurement obtained with prior art apparatus, regardless of whether the well is vertical or whether it is inclined or horizontal.

The method of determining the overall flow rate is based on experimental observation whereby, in an inclined or horizontal well, the various phases are stratified

along substantially horizontal separation lines in a vertical section of the well. Thus, the total section of the well can be divided into a plurality of section elements Δs having horizontal sides. A multi-sensor assembly 24 is associated to each of said section elements Δs . On this basis, the overall or total flow rate of any given phase is equal to the sum of the flow rates of said phase calculated over all the section elements Δs . In other words, in the case where three multi-sensor assemblies 24 are used associated with three respective section elements Δs_1 , Δs_2 , and Δs_3 , the overall flow rate Q is given by the relationship:

$$Q = q_1 \cdot \frac{\Delta s_1}{S} + q_2 \cdot \frac{\Delta s_2}{S} + q_3 \cdot \frac{\Delta s_3}{S}$$

where S represents the total vertical section of the well and q_1 , q_2 , and q_3 represent the flow rates of the phase under consideration in each of the respective section elements Δs_1 , Δs_2 , and Δs_3 , each of said flow rates being equal to the product of the local speed v_1 , v_2 , and v_3 of the phase under consideration multiplied by the local proportion h_1 , h_2 , and h_3 of said phase.

Figure 3 is a diagram showing another embodiment of the apparatus 10 of the invention.

In this case, the body 14 of the data acquisition apparatus 10 is centered about the longitudinal axis of the well 12 via at least two arms 18' and 20' situated in locations that are diametrically opposite about the longitudinal axis of the body 14. As mentioned above, the arms 18' and 20' can be arms that are hinged, deployed, or folded by means of a motor mounted in the body 14, or they can be arms forming springs as shown in Figure 3.

In this second embodiment, the arms 18' and 20' are mounted on the body 14 of the apparatus 10, for example by means of a mechanism enabling said arms to be oriented automatically so as to be situated in the vertical plane

containing the longitudinal axis of the well 12 when the well is inclined or horizontal. Such a mechanism (not shown) can, in particular, comprise a rheostat with a plumb weight delivering a signal representative of the vertical direction. A motor sensitive to said signal thus imparts the desired orientation to the arms 18' and 20'.

In the embodiment in Figure 3, multi-sensor assemblies 24 are mounted in the body 14 and on each of the arms 18' and 20' so as to take measurements in distinct regions of the well, that are evenly distributed over the entire width of the well in a single, vertically-oriented plane containing the longitudinal axis of the well.

In the particular case of Figure 3, a multi-sensor assembly 24 is mounted in the body 14 of the apparatus 10 and two multi-sensor assemblies 24 are mounted on each of the arms 18' and 20'. More precisely, each of the arms 18' and 20' supports a multi-sensor assembly 24 in the immediate vicinity of the walls of the well 12, i.e. of the top and bottom generator lines of the well. Each of the arms 18' and 20' also supports a multi-sensor assembly 24 in a location such that it is positioned radially, substantially mid-way between the body 14 of the apparatus and the bottom and top generator lines of the well.

In a variant, the multi-sensor assembly 24 mounted in the body 14 of the apparatus 10 can be omitted and replaced by two multi-sensor assemblies 24 symmetrically mounted in the immediate vicinity of the body 14 on each of the arms 18' and 20'.

Figure 4 is a diagram showing a variant of the first embodiment of the invention.

This variant differs from the embodiment previously described with reference to Figures 1 and 2 essentially in that the means for determining the local speed of the fluid and the means for determining the local proportions

of the phases are situated in various locations, instead of being included in the multi-sensor assemblies.

More precisely, the mini-spinners 26 forming the means for determining the local speed of the fluid are mounted on the body 14 and on the arm 18, while the local sensors 28 forming the means for determining the local proportions of the phases of said fluid are mounted on the body 14 and on the arm 20. In this case, a mini-spinner 26 and a local sensor 28 are mounted on the body 14 of the apparatus 10 while three mini-spinners 26 and three local sensors 28 are mounted on the arms 18 and 20 of the mechanism 16.

As mentioned above, the mini-spinners 26 and the local sensors 28 are grouped together in pairs so that each assembly formed by a mini-spinner 26 and by a local sensor 28 takes measurements in locations that are in alignment with each other parallel to the longitudinal axis of the well 12, i.e. in the same measurement region for the fluid which flows in the well. In addition, as mentioned above, the measurements taken by the various assemblies formed by a mini-spinner 26 and a local sensor 28 are taken in distinct regions, i.e. not in alignment with each other parallel to the axis of the well 12.

As in the previously-described embodiments, the regions in which the measurements are taken are evenly distributed over the entire width of the well and situated approximately in the same plane containing the axis of the well and oriented in a direction that is substantially vertical whenever the well is inclined or horizontal.

The variant embodiment of Figure 4 presents the same advantages as the two embodiments described with reference to Figures 1 to 3. In addition, it enables the apparatus to be simplified by mounting the mini-spinners and the local sensors in locations that are physically different from the apparatus.

Naturally, the invention is not limited to the embodiments described above by way of example. Thus, it is understood, in particular, that mounting the means for determining the local speed of the fluid and the means
5 for determining the local proportions of the phases in distinct locations, as described with reference to Figure 4, can also apply to the second embodiment as described with reference to Figure 3.

CLAIMS

- 1/ A method of acquiring data in a hydrocarbon well (12), the method being characterized in that it consists in determining both the local speed of a multiphase fluid flowing in the well and the local proportions of the phases of said fluid in each of at least two distinct regions of the well that are offset from each other parallel to the axis of the well.
- 2/ A method according to claim 1, in which said regions are all situated in the same plane containing the axis of the well, or in the vicinity of said plane.
- 3/ A method according to claim 2, in which said regions are distributed across the entire width of the well (12).
- 4/ A method according to claim 2 or 3, in which said plane is oriented in a substantially vertical direction when the well (12) is inclined or horizontal.
- 5/ A method according to claims 3 and 4 combined, in which one of said regions is situated in the vicinity of a top generator line of the well (12).
- 6/ A method according to any preceding claim, in which a section element (Δs_i) of the well is assigned to each of said regions, and the overall flow rate Q of each of said phases is determined from the relationship:

$$Q = \sum_i q_i \cdot \frac{\Delta s_i}{S}$$

where S is the total vertical section of the well and q_i is the flow rate of said phase in section element Δs_i ,
with $q_i = v_i \cdot h_i$

where v_i is the local speed of said phase in section element Δs_i and h_i is the local proportion of said phase in section element Δs_i .

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7/ Apparatus (10) for acquiring data in a hydrocarbon well (12), the apparatus being characterized in that it comprises, in each of at least two distinct regions of the well that are offset from each other parallel to the axis of the well, means (26) for determining the local speed of a multiphase fluid flowing in the well and means (28) for determining the local proportions of the phases of said fluid.

15 8/ An apparatus according to claim 7, in which said regions are all situated in the same plane containing the axis of the well (12).

20 9/ An apparatus according to claim 8, in which said regions are distributed across the entire width of the well (12).

10/ An apparatus according to claim 8 or 9, in which means are provided to orient said plane in a substantially vertical direction when the well (12) is inclined or horizontal.

11/ An apparatus according to claims 8 and 9 combined, in which one of said regions is situated in the vicinity of a top generator line of the well (12).

12/ An apparatus according to claim 10 or 11, comprising a body (14) capable of resting, by gravity, against a bottom generator line of the well (12), and at least one deployable arm (18, 20) supported by the body (14) at one end and capable of being applied against the top generator line of the well, in which at least some of the

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means (26) for determining the local speed of the fluid and at least some of the means (28) for determining the local proportions of the phases are supported by the deployable arm (18, 20).

5

13/ An apparatus according to claim 10 or 11, comprising a body (14) capable of being centered about the axis of the well by centering means including at least two deployable arms (18', 20') supported by the body (14) and
10 capable of being applied respectively against the bottom generator line and against the top generator line of the well, in which at least some of the means (26) for determining the local speed of the fluid and at least some of the means (28) for determining the local
15 proportions of the phases are supported by the deployable arms (18', 20').

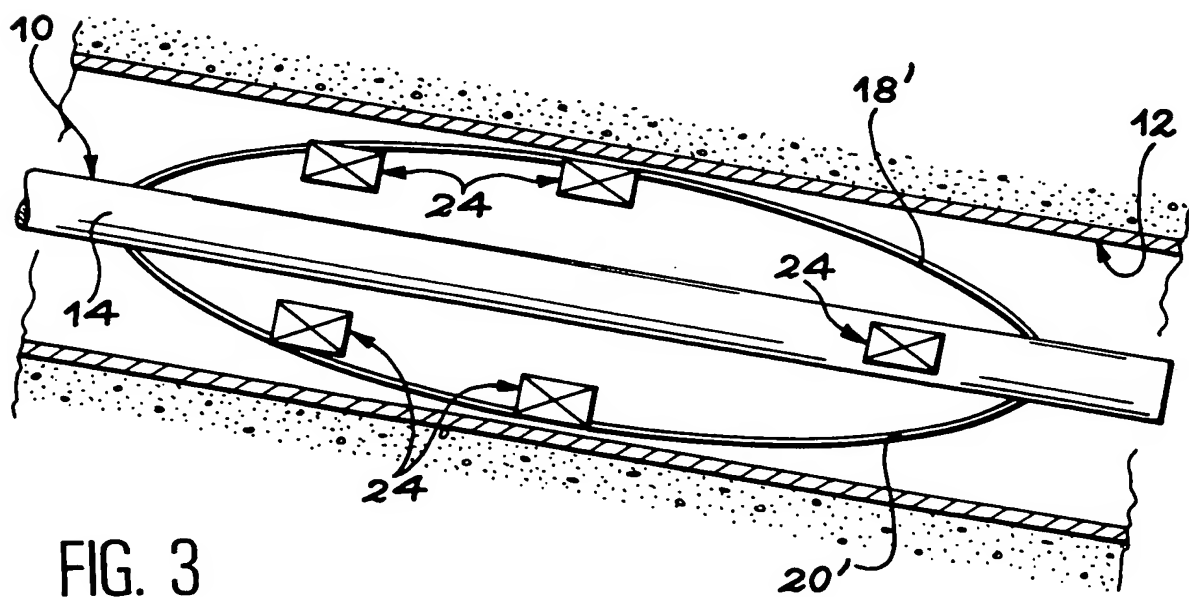
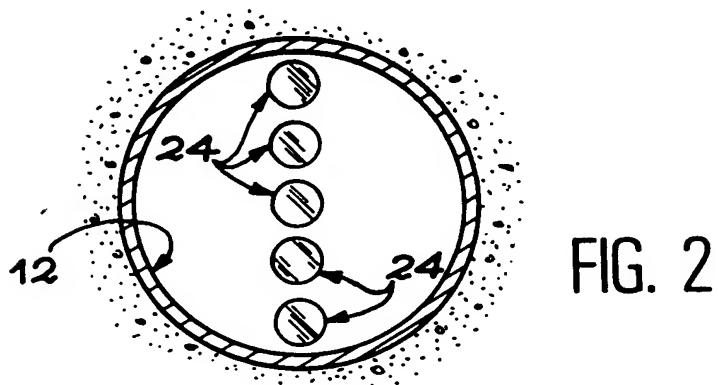
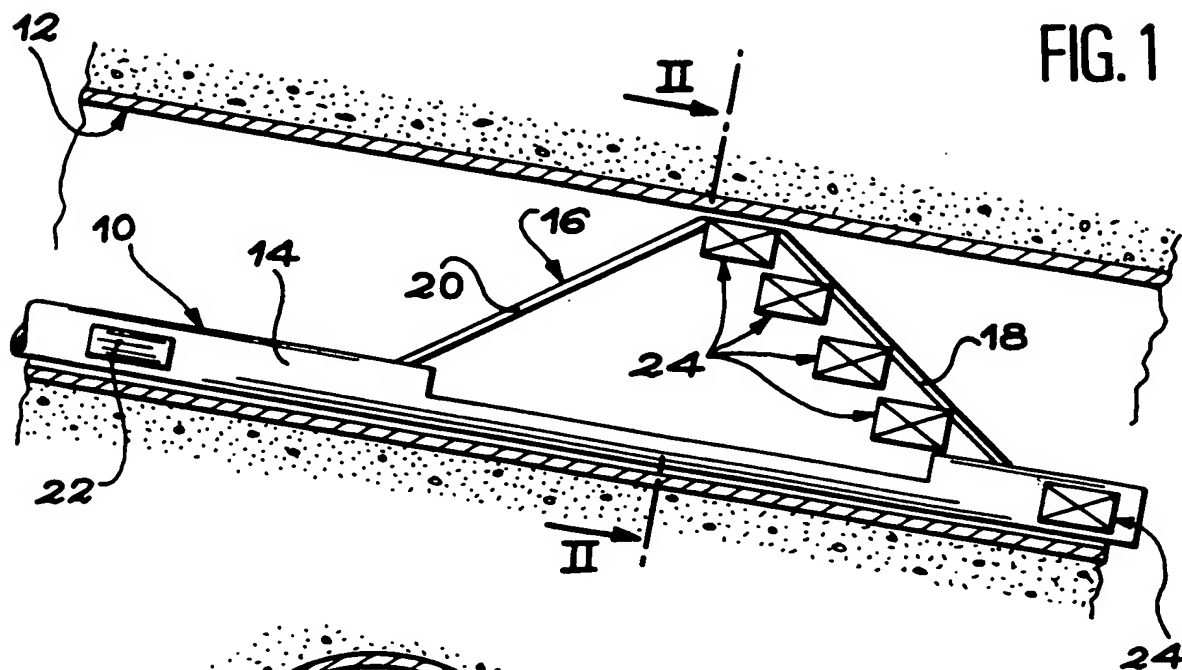
14/ An apparatus according to any one of claims 7 to 13, in which multi-sensor assemblies (24) are provided, each
20 including the means (26) for determining the local speed of the fluid and the means (28) for determining the local proportions of the phases.

15/ An apparatus according to any one of claims 7 to 13, in which, in each of said regions, the means (26) for
25 determining the local speed of the fluid and the means (28) for determining the local proportions of the phases are mounted in distinct locations that are substantially in alignment with each other on a line parallel to the
30 axis of the well.

A B S T R A C T

To acquire data such as the flow rate of various phases of a fluid flowing in a hydrocarbon well (12) in production, in particular in an inclined or horizontal portion of the well, both the local speed of the fluid and the proportions of the various phases are determined in each of at least two distinct regions of the well that are not in alignment with one another parallel to the axis of the well. The regions in which the measurements are taken are advantageously distributed in a vertical plane containing the axis of the well when the well is inclined or horizontal.

1 / 2



2/2

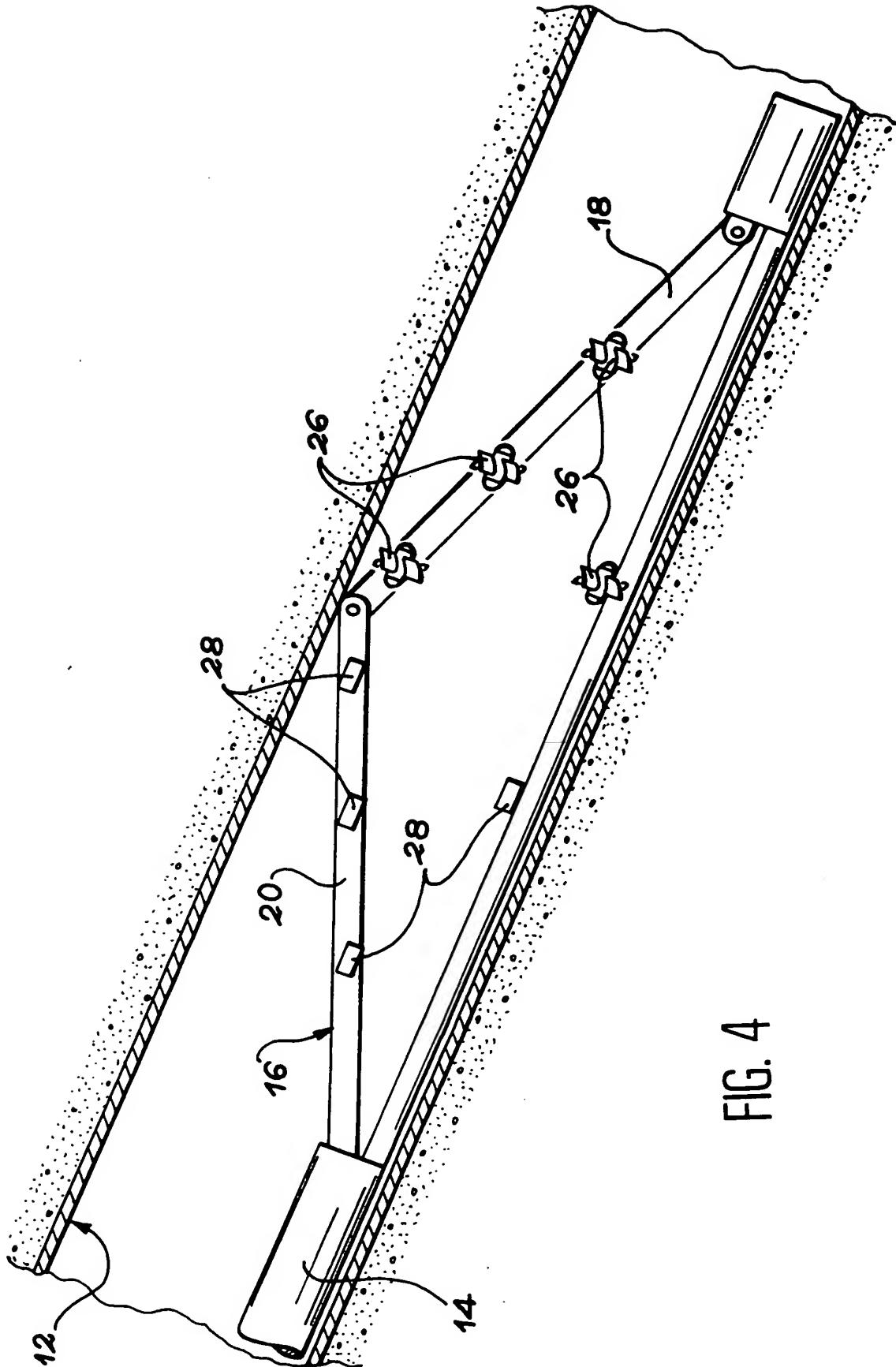




FIG. 4

14
REC'D 15 NOV 2001

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 17.0191		FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/EP00/07285	International filing date (day/month/year) 25/07/2000	Priority date (day/month/year) 05/08/1999	
International Patent Classification (IPC) or national classification and IPC E21B47/10			
Applicant SCHLUMBERGER TECHNOLOGY B.V. et al.			
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 7 sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of 3 sheets.</p>			
<p>3. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> I <input checked="" type="checkbox"/> Basis of the report II <input type="checkbox"/> Priority III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability IV <input type="checkbox"/> Lack of unity of invention V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement VI <input type="checkbox"/> Certain documents cited VII <input checked="" type="checkbox"/> Certain defects in the international application VIII <input checked="" type="checkbox"/> Certain observations on the international application 			
Date of submission of the demand 23/02/2001		Date of completion of this report 13.11.2001	
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465		Authorized officer DIAZ, M Telephone No. +49 89 2399 7534 	

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/07285

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-13 as originally filed

Claims, No.:

1-16 with telefax of 05/10/2001

Drawings, sheets:

1/2,2/2 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/07285

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	5, 6, 11-13
	No:	Claims	1-4, 7-10, 14-16
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-16
Industrial applicability (IA)	Yes:	Claims	1-16
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

- 1) The application does not meet the requirements of Article 6 PCT for the following reasons:

Clarity:

The feature " wherein the region in which the local speed is measured and the region in which the local properties are measured lie in a vertical plane of the well" defines "the region" which has not been claimed and which is not a method step in claim 1. Similarly, claim 8 reads "sensor means mounted on the tool body for measuring local proportions of the fluid flowing in a region of the well, sensor means mounted on the tool body for measuring local speed of the flowing fluid in a region of the well wherein the region in which the local speed is measured and the region in which the local properties are measured lie in a vertical plane of the well", where the sensor means make reference to a second entity ("the region") that has not been claimed (PCT-Guidelines-III, 4.8a). Therefore claims 1 and 8 are unclear.

- 2) Each of D1 (US-A-5 251 479)/D2 (GB-A-2 307 047) discloses a method of determining flow rates in a multiphase fluid flowing in a well (see column 1, lines 7-14/see abstract), comprising:
- measuring local speed of the flowing fluid in a region of the well and (see claim 1, lines 39-41/ see abstract)
 - measuring local proportions of the fluid flowing fluid in a region of the well (see column 4, lines 48-53/see abstract)
 - wherein the region in which the local speed is measured and the region in which the local properties are measured lie in a vertical plane of the well (see plane formed by arms 18 and tool 10/see plane formed by 10 and 24) wherein
 - the method comprises measuring both local speed and local proportions of the phases in at least two regions that lie in a vertical plane of the well which includes the longitudinal axis of the well and are offset from each other parallel to the axis of the well (see figs. 1 and 5/ see fig. 3 where the vertical plane, where the regions are, cuts the bore lengthways across the axis of the well).

Thus the subject-matter of claim 1 is known.

Further, each of D1/D2 discloses an apparatus for determining flow rates in a multiphase fluid flowing in a well comprising:

- a tool body (10/10) to be positioned in the well
- sensor means (26/20, 22) mounted on the tool body for measuring local speed of the flowing fluid in a region of the well
- sensor means (35/31, 32) mounted on the tool body for measuring local proportions of the fluid flowing in a region of the well
- wherein the region in which the local speed is measured and the region in which the local properties are measured lie in a vertical plane of the well (see figs. 1 and 5/ see fig. 3 where the vertical plane cuts the bore lengthways across the axis of the well)
- wherein the sensor means are provided for measuring both the local speed and local proportions of the phases in at least two regions that lie in a vertical plane of the well which includes the longitudinal axis of the well and are offset from each other parallel to the axis of the well (see figs. 1 and 5/ see fig. 3).

Thus the subject-matter of claims 8 and 16 is known.

Therefore, the subject-matter of claims 1, 8 and 16 does not meet the novelty requirements of Art. 3(2) PCT.

3) Further D1 discloses the additional features of claims:

- 2-4, 9-10 (see items 18 and 18a in fig. 2)
- 7 (see item 18a in fig. 2)
- 14 (see item 17 for the centering means in fig. 1)
- 15 (see item 18 for the multi-sensor assembly in fig. 2)

Therefore the subject-matter of claims 2-4, 7, 9-10, 14-15 is known and claims 2-4, 7, 9-10, 14-15 do not meet the novelty requirements of Art. 3(2) PCT.

4) Further D2 discloses the additional features of claims:

- 7 (fig. 3 with 30 in a non-deployed position)
- 11 (see item 22 in fig. 3)
- 12 (see item 11)
- 13 (see item 24 and 30 for the deployable arms in fig. 3)

Therefore, the subject-matter of claims 7, 11-13 does not involve an inventive step (Art. 33(3) PCT).

- 4) The subject-matter of claim 5 appears not inventive in view of D2 (see page 8, lines 17-19). The relationship claimed in claim 6 is not disclosed in D2, but it is from common knowledge that in order to calculate a total value, having the partial values, a summation of the partial values is needed. Therefore, the subject-matter of claim 5 does not involve an inventive step Art. 33(3) PCT.
- 5) Dependant claim 6 propose additional features which appear to be a matter of normal design procedure for the skilled person.

Therefore, the subject-matter of claim 6 does not involve an inventive step (Art. 33(3) PCT).

Re Item VII

Certain defects in the international application

If the applicant files new clarified claims, following should be taken into account:

- Rule 6.3 (b) PCT: correct two-part form of independant claims 1 and 8 with regard to D1/D2.
- Rules 5.1 (a) (ii) PCT reference to the document D1 and its disclosure.

The subject-matter of the independant claims should include some technical difference over the disclosure of document D1, considered in combination, so as to permit a finding that that claim has inventive step over the prior art.

- Rule 5.1 (a) (iii) PCT: description in conformity with the new claims.
- Art. 34 (2) (b) PCT: The applicants are requested to identify in their reply those passages of the application as originally filed which form a basis for the

amendments.

Re Item VIII

Certain observations on the international application

- 1) The terms "bottom or top of the vertical plane of the well" in claims 3, 4, 10 and 11 are ambiguous since a plane is defined by two straight lines and has two infinite dimensions. A possible definition would be: the surface defined by the longitudinal cross-section of the well across the longitudinal axis of the well and perpendicular to the surface.
 - 2) Claims 13 and 14 read "top of the well" and "bottom and top of the well" respectively, if the applicant means bottom and/or top of the vertical plane of the well, then point 1 of this item applies.
-
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(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
15 February 2001 (15.02.2001)

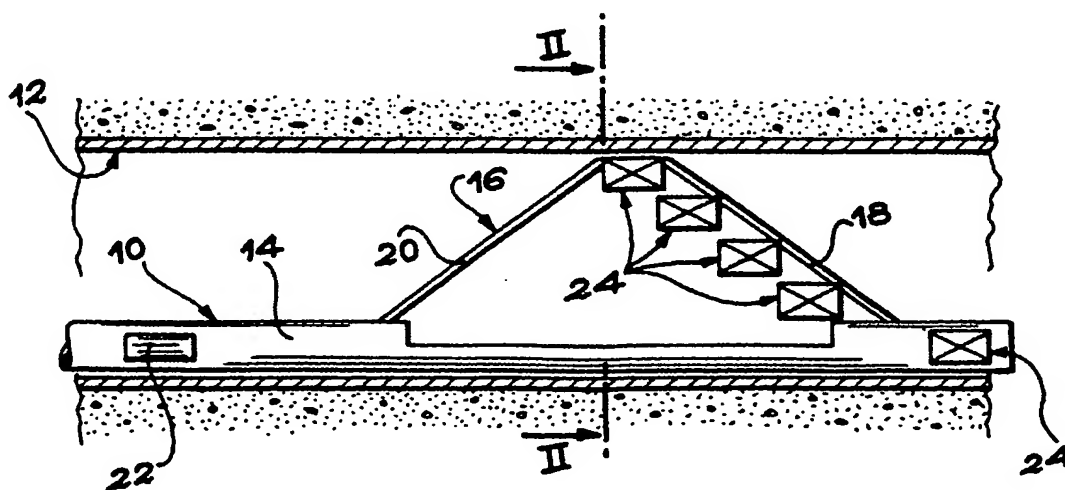
PCT

(10) International Publication Number
WO 01/11190 A1

- (51) International Patent Classification⁷: **E21B 47/10, G01F 1/74**
- (21) International Application Number: **PCT/EP00/07285**
- (22) International Filing Date: **25 July 2000 (25.07.2000)**
- (25) Filing Language: **English**
- (26) Publication Language: **English**
- (30) Priority Data:
99/10197 5 August 1999 (05.08.1999) FR
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- (81) Designated States (national): **AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.**

[Continued on next page]

(54) Title: **A METHOD AND APPARATUS FOR ACQUIRING DATA IN A HYDROCARBON WELL IN PRODUCTION**



(57) Abstract: To acquire data such as the flow rate of various phases of a fluid flowing in a hydrocarbon well (12) in production, in particular in an inclined or horizontal portion of the well, both the local speed of the fluid and the proportions of the various phases are determined in each of at least two distinct regions of the well that are not in alignment with one another parallel to the axis of the well. The regions in which the measurements are taken are advantageously distributed in a vertical plane containing the axis of the well when the well is inclined or horizontal.



(84) **Designated States (regional):** ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

CLAIMS

- 1 A method of determining flow rates in a multiphase fluid flowing in a well, comprising:
 - (i) measuring local speed of the flowing fluid in a region of the well; and
 - (ii) measuring local proportions of the fluid flowing in a region of the well;
 wherein the region in which the local speed is measured and the region in which the local properties are measured lie in a vertical plane of the well; characterised in that the method comprises measuring both local speed and local proportions of the phases in at least two regions that lie in a vertical plane of the well which includes the longitudinal axis of the well and are offset from each other parallel to the axis of the well.
- 2 A method as claimed in claim 1, comprising measuring local speed and local proportions of phases at regions distributed across the entire width of the well.
- 3 A method as claimed in claim 2, wherein the well is inclined from vertical, the method comprising measuring local speed and local proportions of phases at a region lying at the bottom of the vertical plane of the well, and measuring local speed and local proportions of phases at other regions distributed across the entire width of the well in the vertical plane.
- 4 A method as claimed in claim 3, further comprising measuring local speed and local proportions of phases at a region lying at the bottom of the vertical plane of the well.
- 5 A method as claimed in any preceding claim, in which a section element (Δs_i) of the well is assigned to each region, and the overall flow rate Q of each phase is determined from the relationship:

$$Q = \sum_i q_i \cdot \frac{\Delta s_i}{S}$$

where S is the total vertical section of the well
 and q_i is the flow rate of each phase in section element Δs_i ,
 with $q_i = v_i \cdot h_i$

where v_i is the local speed of each phase in section element Δs_i
and h_i is the local proportion of each phase in section element Δs_i .

- 6 A method as claimed in any preceding claim, comprising measuring the local speed and local proportions of the phases at the same point in each region.
- 7 A method as claimed in any of claims 1 – 5, comprising, in each region, measuring local speed and local proportions of phases in different locations that are aligned with each other parallel to the longitudinal axis of the well.
- 8 Apparatus for determining flow rates in a multiphase fluid flowing in a well, comprising:
 - (i) a tool body to be positioned in the well;
 - (ii) sensor means mounted on the tool body for measuring local speed of the flowing fluid in a region of the well; and
 - (iii) sensor means mounted on the tool body for measuring local proportions of the fluid flowing in a region of the well;wherein the region in which the local speed is measured and the region in which the local properties are measured lie in a vertical plane of the well;
characterised in that sensor means are provided for measuring both local speed and local proportions of the phases in at least two regions that lie in a vertical plane of the well which includes the longitudinal axis of the well and are offset from each other parallel to the axis of the well.
- 9 Apparatus as claimed in claim 8, wherein, in use, the sensor means for measuring local speed and local proportions of phases at regions distributed across the entire width of the well.
- 10 Apparatus as claimed in claim 9, wherein when the well is inclined from vertical, sensor means are provided for measuring local speed and local proportions of phases at a region lying at the bottom of the vertical plane of the well and for measuring local speed and local proportions of phases at other regions distributed across the entire width of the well in the vertical plane.

- 11 Apparatus as claimed in claim 10, further comprising sensor means are provided for measuring local speed and local proportions of phases at a region lying at the top of the vertical plane of the well
- 12 Apparatus as claimed in claim 9, 10 or 11, further comprising means for orienting the tool body such that the sensor means lie across the entire width of the well in the vertical plane.
- 13 Apparatus as claimed in any of claims 8 – 12, wherein, in use, the tool body rests under the influence of gravity, against the bottom of the well (12), and including at least one deployable arm (18, 20) supported by the body (14) at one end and capable of being applied against the top of the well, in which at least some of the sensor means (26) for determining the local speed of the fluid and at least some of the sensor means (28) for determining the local proportions of the phases are mounted on the deployable arm (18, 20).
- 14 Apparatus as claimed in any of claims 8 – 12, wherein, in use, the tool body (14) is centered about the axis of the well by centering means including at least two deployable arms (18', 20') mounted on the body (14) and capable of being applied respectively against the bottom and top of the well, in which at least some of the sensor means (26) for determining the local speed of the fluid and at least some of the sensor means (28) for determining the local proportions of the phases are mounted on the deployable arms (18', 20').
- 15 Apparatus as claimed in any of claims 8 – 12, wherein the sensor means comprise multi-sensor assemblies (24), each including the means (26) for determining the local speed of the fluid and the means (28) for determining the local proportions of the phases.
- 16 Apparatus as claimed in any of claims 8 – 14, wherein, in use, the sensor means (26) for determining the local speed of the fluid and the sensor means (28) for determining the local proportions of the phases are mounted in distinct locations in each region that are substantially in alignment with each other parallel to the axis of the well.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

SERVICE BREVETS & CONTRATS

Reçu
le

16 NOV. 2001

PCT

SRPC - Clamart

To:

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F-92142 Clamart Cedex
FRANCE

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL PRELIMINARY
EXAMINATION REPORT

(PCT Rule 71.1)

16/11/01

→ NAT PHASE

Date of mailing
(day/month/year)

13.11.2001

Applicant's or agent's file reference
17.0191

IMPORTANT NOTIFICATION

International application No.
PCT/EP00/07285

International filing date (day/month/year)
25/07/2000

Priority date (day/month/year)
05/08/1999

Applicant
SCHLUMBERGER TECHNOLOGY B.V. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

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PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 17.0191	<div style="display: flex; justify-content: space-between;"> <div> FOR FURTHER ACTION </div> <div> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416) </div> </div>	
International application No. PCT/EP00/07285	International filing date (day/month/year) 25/07/2000	Priority date (day/month/year) 05/08/1999
International Patent Classification (IPC) or national classification and IPC E21B47/10		
Applicant SCHLUMBERGER TECHNOLOGY B.V. et al.		
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 7 sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of 3 sheets.</p>		
<p>3. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> I <input checked="" type="checkbox"/> Basis of the report II <input type="checkbox"/> Priority III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability IV <input type="checkbox"/> Lack of unity of invention V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement VI <input type="checkbox"/> Certain documents cited VII <input checked="" type="checkbox"/> Certain defects in the international application VIII <input checked="" type="checkbox"/> Certain observations on the international application 		
Date of submission of the demand 23/02/2001	Date of completion of this report 13.11.2001	
Name and mailing address of the international preliminary examining authority: <div style="display: flex; align-items: center;"> <div> European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465 </div> </div>	Authorized officer DIAZ, M Telephone No. +49 89 2399 7534	



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/07285

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-13 as originally filed

Claims, No.:

1-16 with telefax of 05/10/2001

Drawings, sheets:

1/2,2/2 as originally filed

2. ~~With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.~~

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/07285

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	5, 6, 11-13
	No:	Claims	1-4, 7-10, 14-16
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-16
Industrial applicability (IA)	Yes:	Claims	1-16
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

- 1) The application does not meet the requirements of Article 6 PCT for the following reasons:

Clarity:

The feature "wherein the region in which the local speed is measured and the region in which the local properties are measured lie in a vertical plane of the well" defines "the region" which has not been claimed and which is not a method step in claim 1. Similarly, claim 8 reads "sensor means mounted on the tool body for measuring local proportions of the fluid flowing in a region of the well, sensor means mounted on the tool body for measuring local speed of the flowing fluid in a region of the well wherein the region in which the local speed is measured and the region in which the local properties are measured lie in a vertical plane of the well", where the sensor means make reference to a second entity ("the region") that has not been claimed (PCT-Guidelines III, 4.8a). Therefore claims 1 and 8 are unclear.

- 2) Each of D1 (US-A-5 251 479)/D2 (GB-A-2 307 047) discloses a method of determining flow rates in a multiphase fluid flowing in a well (see column 1, lines 7-14/see abstract), comprising:
- measuring local speed of the flowing fluid in a region of the well and (see claim 1, lines 39-41/ see abstract)
 - measuring local proportions of the fluid flowing fluid in a region of the well (see column 4, lines 48-53/see abstract)
 - wherein the region in which the local speed is measured and the region in which the local properties are measured lie in a vertical plane of the well (see plane formed by arms 18 and tool 10/see plane formed by 10 and 24) wherein
 - the method comprises measuring both local speed and local proportions of the phases in at least two regions that lie in a vertical plane of the well which includes the longitudinal axis of the well and are offset from each other parallel to the axis of the well (see figs. 1 and 5/ see fig. 3 where the vertical plane, where the regions are, cuts the bore lengthways across the axis of the well).

Thus the subject-matter of claim 1 is known.

Further, each of D1/D2 discloses an apparatus for determining flow rates in a multiphase fluid flowing in a well comprising:

- a tool body (10/10) to be positioned in the well
- sensor means (26/20, 22) mounted on the tool body for measuring local speed of the flowing fluid in a region of the well
- sensor means (35/31, 32) mounted on the tool body for measuring local proportions of the fluid flowing in a region of the well
- wherein the region in which the local speed is measured and the region in which the local properties are measured lie in a vertical plane of the well (see figs. 1 and 5/ see fig. 3 where the vertical plane cuts the bore lengthways across the axis of the well)
- wherein the sensor means are provided for measuring both the local speed and local proportions of the phases in at least two regions that lie in a vertical plane of the well which includes the longitudinal axis of the well and are offset from each other parallel to the axis of the well (see figs. 1 and 5/ see fig. 3).

Thus the subject-matter of claims 8 and 16 is known.

Therefore, the subject-matter of claims 1, 8 and 16 does not meet the novelty requirements of Art. 3(2) PCT.

3) Further D1 discloses the additional features of claims:

- 2-4, 9-10 (see items 18 and 18a in fig. 2)
- 7 (see item 18a in fig. 2)
- 14 (see item 17 for the centering means in fig. 1)
- 15 (see item 18 for the multi-sensor assembly in fig. 2)

Therefore the subject-matter of claims 2-4, 7, 9-10, 14-15 is known and claims 2-4, 7, 9-10, 14-15 do not meet the novelty requirements of Art. 33(2) PCT.

4) Further D2 discloses the additional features of claims:

- 7 (fig. 3 with 30 in a non-deployed position)
- 11 (see item 22 in fig. 3)
- 12 (see item 11)
- 13 (see item 24 and 30 for the deployable arms in fig. 3)

Therefore, the subject-matter of claims 7, 11-13 does not involve an inventive step (Art. 33(3) PCT).

- 4) The subject-matter of claim 5 appears not inventive in view of D2 (see page 8, lines 17-19). The relationship claimed in claim 6 is not disclosed in D2, but it is from common knowledge that in order to calculate a total value, having the partial values, a summation of the partial values is needed. Therefore, the subject-matter of claim 5 does not involve an inventive step Art. 33(3) PCT.
- 5) Dependant claim 6 propose additional features which appear to be a matter of normal design procedure for the skilled person.

Therefore, the subject-matter of claim 6 does not involve an inventive step (Art. 33(3) PCT).

Re Item VII

Certain defects in the international application

If the applicant files new clarified claims, following should be taken into account:

- Rule 6.3 (b) PCT: correct two-part form of independant claims 1 and 8 with regard to D1/D2.
- Rules 5.1 (a) (ii) PCT reference to the document D1 and its disclosure.

The subject-matter of the independant claims should include some technical difference over the disclosure of document D1, considered in combination, so as to permit a finding that that claim has inventive step over the prior art.

- Rule 5.1 (a) (iii) PCT: description in conformity with the new claims.
- Art. 34 (2) (b) PCT: The applicants are requested to identify in their reply those passages of the application as originally filed which form a basis for the

amendments.

Re Item VIII

Certain observations on the international application

- 1) The terms "bottom or top of the vertical plane of the well" in claims 3, 4, 10 and 11 are ambiguous since a plane is defined by two straight lines and has two infinite dimensions. A possible definition would be: the surface defined by the longitudinal cross-section of the well across the longitudinal axis of the well and perpendicular to the surface.
 - 2) Claims 13 and 14 read "top of the well" and "bottom and top of the well" respectively, if the applicant means bottom and/or top of the vertical plane of the well, then point 1 of this item applies.
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